ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 FEBRUARY 10–16.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on February 10

Sun rises, 7h. 24m.; souths, 12h. 14m. 28·9s.; sets, 17h. 4m.: right asc. on meridian, 21h. 37·5m.; decl. 14° 11′ S. Sidereal Time at Sunset, 2h. 28m.

Moon (Full on February 15, 22h.) rises, 12h. 7m.; souths, 20h. 12m.; sets, 4h. 23m.*: right asc. on meridian, 5h. 36·5m.; decl. 21° 1′ N.

Planet.	Rises.		Souths.		Sets.		Right asc. and declination on meridian.			
	h.	m.	h.	m.	h.	m.	h.	m.	°	′
Mercury..	7	23 ...	12	45 ...	18	7 ...	22	8·0 ...	8	8 S.
Venus ...	8	41 ...	15	6 ...	21	31 ...	0	29·9 ...	4	14 N.
Mars ...	8	28 ...	14	19 ...	20	10 ...	23	42·0 ...	2	39 S.
Jupiter ...	4	46 ...	8	41 ...	12	36 ...	18	3·5 ...	23	6 S.
Saturn ...	16	18 ...	23	52 ...	7	26*...	9	17·1 ...	17	1 N.
Uranus...	22	37*...	4	0 ...	9	23 ...	13	21·9 ...	7	56 S.
Neptune..	10	44 ..	18	27 ...	2	10*...	3	50·8 ...	18	25 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Feb.	h.	
15 ...	1 ...	Mercury in inferior conjunction with the Sun.
15 ...	1 ...	Saturn in conjunction with and 1° 5′ south of the Moon.

Variable Stars.

Star.	R.A.		Decl.				h.	m.	
	h.	m.	°						
U Cephei	0	52·5 ...	81	17 N. ...	Feb.	12,	19	30	*m*
Algol	3	1·0 ...	40	32 N. ...	,,	11,	0	59	*m*
					,,	16,	18	37	*m*
λ Tauri...	3	54·6 ...	12	11 N. ...	,,	13,	19	39	*m*
ζ Geminorum ...	6	57·5 ...	20	44 N. ...	,,	12,	6	0	*M*
R Canis Majoris...	7	14·5 ...	16	11 N. ...	,,	14,	20	7	*m*
					and at intervals of		27	16	
R Virginis	12	32·9 ...	7	36 N. ...	Feb.	11,			*M*
U Coronæ	15	13·7 ...	32	3 N. ...	,,	14,	20	34	*m*
Y Cygni	20	47·6 ...	34	14 N. ...	,,	11,	5	40	*m*
					and at intervals of		36	0	
δ Cephei	22	25·0 ...	57	51 N. ...	Feb.	12,	0	0	*m*
R Lacertæ	22	38·3 ...	41	47 N. ...	,,	15,			*M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
From Camelopardalis ...	110° ...	62° N. ...	Slow.
,, Monoceros	120 ...	5 S. ...	Slow.
Near β Ophiuchi	263 ...	2 N. ...	Very swift.

GROWTH OF OUR KNOWLEDGE OF THE NEBULÆ.

OUR present knowledge of those celestial bodies which we term nebulæ may be said to date from a paper by Sir William Herschel on nebulous stars, published in 1791 (Phil. Trans., vol. lxxxi. p. 71). It is perfectly true that we have not here the first recorded observations of nebulæ: several observers before Sir William Herschel, and Sir William Herschel himself, had previously referred to them. All observers previous to Sir William Herschel, among whom we may include Kepler, Tycho Brahé, Halley, and others, were of opinion that the nebulæ were composed of something differing entirely in its essence from stars. There was no question whatever of their being simply clusters of stars considerably removed. Tycho Brahé, in the record of his observations of the new star observed by him in Cassiopeia, suggested that it was in some way generated from an ethereal substance, and to him the Milky Way was composed of the same material. This ethereal substance was liable to dissipation by light and heat, and in this way he accounted for the ultimate disappearance of the star. Kepler shared this opinion, and it may be stated that it was generally accepted at the time that Sir William Herschel began his observations of nebulæ about the year 1780. His first important paper, however, did not deal with these objects: it had reference to the motion of the sun in space (Phil. Trans., vol. lxxiii., published in 1783). In this memoir he points out the universal sway of gravitation in the celestial spaces; and the infinite possibilities opened out by such an all-prevailing and pervading cause seem, although he does not state it in terms, to have led him to the conclusion that such ideas as Brahé's and Kepler's were invalid. His first real survey of the nebulæ appears in his paper of 1784 (Phil. Trans., vol. lxxiii.) He began by observing those bodies which had already been recorded in the *Connaissance des Temps* for 1783, and then those further afield; and it is not a little remarkable that in this first paper he describes almost every distinct form of nebulæ which has been observed from that day to the years about 1846, when Lord Rosse brought a still more powerful instrument than Herschel's largest to bear upon these objects. He noticed that in certain parts of the heavens there was a marked absence of stars, and that this was so invariably followed by the appearance of nebulæ on the confines of the empty region that he records in his memoir that after passing over one of them he was in the habit of giving the word to his assistant to "prepare for nebulæ." This strengthened his view as to the power of gravitation, and as to nebulæ being masses of stars produced by it.

In another paper published in the next year (Phil. Trans., vol. lxxv.) he shows evidently that to him the nebulæ of all orders which he had discovered were simple agglomerations of stars, and he refers to the action of gravity in bringing about such condensations. In the next year (Phil. Trans., vol. lxxvi.) he published the first catalogue of a thousand nebulæ, and gives his first classification, one based upon brightness (p. 466). In 1789, that is three years later (Phil. Trans., vol. lxxix.), he published his second catalogue, and it is clear from the text that he still considered nebulæ to be all distinct star clusters. It required another interval of three years before the possibility of their nature being in any way distinct was brought fairly before his mind. In 1791 (Phil. Trans., vol. lxxxi.) he published his remarkable paper on "Nebulous Stars properly so-called." In this paper it will be seen how convincing was the line of argument which Herschel followed to bring him ultimately to the conclusion that in the bodies which he observed there was either a central body which is not a star, or a star involved in a shining fluid of a nature totally unknown to us (p. 83).

This conclusion seems to have made a profound impression upon Herschel's mind, and we had to wait for ten years before he returned to the subject. He did so in 1801 (Phil. Trans., vol. ci.), in a paper detailing "Astronomical Observations relating to the Construction of the Heavens, arranged for the purpose of a critical examination, the result of which appears to throw some new light upon the organization of the celestial bodies." In this paper he classifies all the different kinds of nebulæ which were then known to him, and specimens of which, as has been before stated, he really seems to have glimpsed in his paper of 1784. He points out that, in the classification which he proceeds to give, the bodies under consideration are treated in such a manner that each shall assist us to understand the nature and construction of the others; and he endeavours to attain this end by assorting them into as many classes as are required to produce the most gradual affinity between the individuals contained in any one class and those contained in that which precedes and that which follows it (p. 271). He remarks: "This consideration will be a sufficient apology for the great number of assortments into which I have thrown the bodies under consideration."

His classification may be stated as follows:—

1. *Extensive diffused nebulosity.*—Under this title he includes faint nebulosities stretching and branching over various portions of the sky, which he was the first to discover by means of the enormously increased optical power which he brought to bear. He states that "they can only be seen when the air is perfectly clear, and when the observer has been in the dark long enough for the eye to recover from having been in the light" (p. 274). He gives fifty-two of these diffused nebulosities, which he had observed in the nineteen years from 1783 to 1802. He remarks that "extensive diffused nebulosity is very great indeed; for the amount of it, as given in the tables, is 151·7 square degrees; but this, it must be remembered, gives us by no means the real limits of it;" and he finally adds, "it will be evident that the abundance of nebulous matter diffused through such an expansion of the heavens must exceed all imagination."

2. *Nebulosities joined to nebulæ.*—He refers to fourteen

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objects in which real nebulæ are distinctly associated with the above diffused nebulosity.

3. *Detached nebulosities.*—He next mentions six cases in which, instead of the extensive diffusion referred to under the first head, the nebulosity is found detached.

4. *Milky nebulæ.*—He here remarks that when detached nebulosities are small we are used to call them nebulæ, and he shows that the nebulosities and the nebulæ, whatever may be their appearance, as well as those expressly called by him "milky," partake of the same general nature.

5. *Milky nebulæ with condensations.*—He refers to the brightest portions of the nebula in Orion as an indication of what he means by condensation; then to another in which the greatest brightness lies towards the middle; and then he adds:—"By attending to the circumstances of the size and figures of this nebula we find that we can account for its greater brightness towards the middle in the most simple manner by supposing the nebulous matter of which it is composed to fill an irregular kind of solid space, and that it is either a little deeper in the brightest place, or that the nebulosity is perhaps a little more compressed. It is not necessary for us to determine at present to which of these causes the increase of brightness may be owing; at all events it cannot be probable that the nebulous matter should have different powers of shining, such as would be required independent of depth or compression" (p. 282).

6. *Nebulæ which are brighter in more than one place.*—He associates the general swelling of the nebulous matter about the places which appear like nuclei with the unequally bright places in the diffused nebulosities, and further on he refers to universal gravitation "as a cause of every condensation, agglomeration, compression, and concentration of nebulous matter."

7. *Double nebulæ with joining nebulosity.*—He points out that "in fifteen objects two nuclei or centres of attraction have been observed, and that if the active principle of condensation carries on its operation a diffusion of their at present united nebulosities must in the end be the consequence" (p. 285).

8. *Double nebulæ not more than 2′ from each other.*—He points out that there are twenty-three of this class.

9. *Double nebulæ at a greater distance than 2′ from each other.*—Of these he gives a hundred examples, pointing out that "there are not more than five or six which differ so much in brightness from one another that we can suppose them to be at any very considerably different distance from us" (p. 288), and he further adds that "equal brightness or faintness runs through them all in general."

10. *Treble, quadruple, and sextuple nebulæ.*—He refers to twenty treble, five quadruple, and one sextuple object of each kind.

11. *Very narrow long nebulæ.*

12. *Extended nebulæ.*

13. *Irregular nebulæ.*

14. *Nebulæ that are of an irregular round figure.*

15. *Round nebulæ.*

16. *Nebulæ that are remarkable for some peculiarity of figure or brightness.*—He ascribes this irregularity to the as yet imperfect concentration of the nebulous mass in which the preponderating matter is not in the centre (p. 300).

17. *Nebulæ that are gradually a little brighter in the middle.*

18. *Nebulæ which are gradually brighter in the middle.*

19. *Nebulæ that are gradually much brighter in the middle.*

20. *Nebulæ that are suddenly much brighter in the middle.*

21. *Round nebulæ increasing gradually in brightness up to a nucleus in the middle.*

22. *Nebulæ that have a nucleus.*

23. *Round nebulæ that show a progression of condensation.*

24. *Round nebulæ that are of an almost uniform light.*

25. *Nebulæ that have a cometic appearance.*

26. *Extended nebulæ that show the progress of condensation.*

27. *Nebulæ that draw progressively towards the period of final condensation.*

28. *Planetary nebulæ.*

In addition, Sir William Herschel in his various papers gives drawings illustrating the classification which has been above referred to (Phil. Trans., vol. ci. Plates 4 and 5, and vol. civ. Plate 11). A more elaborate set of plates illustrating the various gradations of the different forms will be found accompanying Sir John Herschel's catalogue (Phil. Trans., vol. cxxiii., 1833, Plates 9, 10, 11, 12, and 13). In these illustrations will be found some forms of great interest not referred to by the elder Herschel. Long parallel nebulæ, for instance, with a dark streak separating them, and elliptic and ring nebulæ. With these exceptions, all the illustrations readily fall into Sir William Herschel's classification.

In the valuable paper of Sir John Herschel, to which reference has been made, there is evidence to show that he gives up the idea of nebulous matter distinct from stars advocated by his father. He says: "If the nebula be anything more than a cluster of discrete stars, as we have every reason to believe, at least in the generality of cases, no pressure can be propagated through it" (Phil. Trans., 1833, vol. cxxiii. p. 502). Coming down to the work of Lord Rosse, we find that as early as 1846 he had convinced himself almost completely that no such thing as so-called nebulous fluid existed. In a letter to Nicol ("Architecture of the Heavens," p. 143) under date March 19, referring to the nebula of Orion, he states that he could "plainly see that all about the trapezium is a mass of stars, the rest of the nebula also abounding with stars and exhibiting the characteristics of resolvability strongly marked."

The magnificent observations of the nebulæ made by Lord Rosse will be found in the Philosophical Transactions (R. S.) for the years 1850 and 1861, the latter giving an account of the work done by the 6-foot, and in the Scientific Transactions of the Royal Dublin Society for 1880. In the volume for 1861, p. 702, Lord Rosse seems rather inclined to withdraw the very definite letter which has been previously quoted, and states that, "When the letter R, meaning that the nebula is resolvable, has been used, he does not attach much importance to the expression of opinion it conveys, because the question of resolvability can only be successfully investigated when the air is steady and the speculum is in fine order."

This state of uncertainty, however, did not last long, for in 1864 Dr. Huggins and Dr. Miller demonstrated that the spectrum of several planetary and other nebulæ which they examined, instead of giving spectra like those of the stars, gave one of bright lines, one of the lines being due, as they asserted at the time, to hydrogen; the other, as it lay very near a line of nitrogen, was supposed by them to represent "a form of matter more elementary than nitrogen, and which our analysis has not yet enabled us to detect" (Phil. Trans., 1864, p. 444). Then they wrote:—"It is obvious that the nebulæ (that they had examined) can no longer be regarded as agglomerations of suns after the order to which our sun and the fixed stars belong. We have in these bodies to do no longer with a special modification only of our own type of suns, but find ourselves in the presence of bodies possessing a distinct and separate plan of structure."

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE forty-second annual general meeting of the Institution of Mechanical Engineers took place at 25 Great George Street, Westminster, by permission of the Council of the Institution of Civil Engineers, on January 30 and 31, and February 1, the President, Mr. Charles Cochrane, in the chair.

The three papers down for reading and discussion were: supplementary paper on the use of petroleum refuse as fuel in locomotive engines, by Mr. Thomas Urquhart, Locomotive Superintendent, Grazi and Tsaritsin Railway, South-East Russia; on compound locomotives, by Mr. R. Herbert Lapage, of London; on the latest development of roller flour milling, by Mr. Henry Simon, of Manchester.

The author of the first paper states that his object is to bring before the Institution the more recent results of his experience in the use of petroleum refuse as a locomotive fuel, now being used on an unprecedented scale on the Grazi and Tsaritsin Railway. Since the publication of the original paper in 1884, nothing new in principle has been discovered, and the same appliances have been used, having undergone very slight modifications, dictated by experience and constant observation. The whole of the 143 locomotives under the author's superintendence, as well as various stationary boilers of various types, have been fired with petroleum refuse, to the complete exclusion of all solid fuel, as well as in all the heating furnaces at the Company's Central Works at Boriooglebsk. The petroleum refuse is burnt in the form of a spray, being blown into the furnace against a brick structure, serving the double purpose of a reservoir for the heat, and against which the spray is broken up. Many experiments were made with a variety of forms of

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